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(54) Four-stroke internal combustion engine with rotary sleeve.

(57) Four stroke internal combustion engine, of high mechanical simplicity, wherein the piston skirt (5) of each cylinder (1) is separated from the latter and rotates in touch with the internal surface of said cylinder, without axial translation, at a speed equal to half the speed of the crankshaft (7) of the engine, a port or window (8) at least being provided on said rotating skirt, the size and location of said port or window being such as to be caused to coincide, during the rotation, with analogous intake and exhaust openings (9) correspondingly provided on said cylinder; the rotation of said skirt being obtained by drive gearings placed between said crankshaft and the lower end of said skirt, so as to allow, through the continuous rotation of said skirt at half the speed of the crankshaft, the realization of the four phases of the four-stroke cycle.

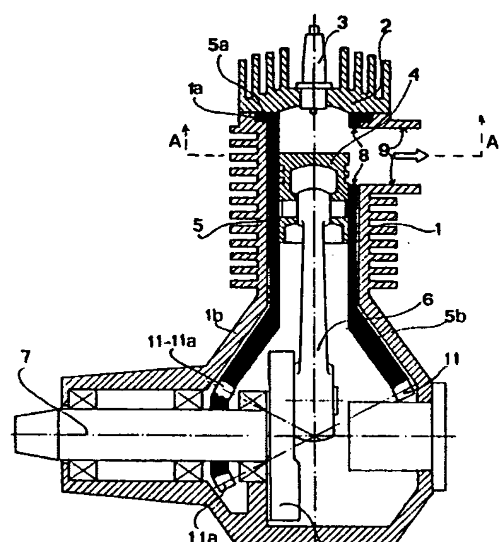

FIG.1

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This invention relates to a "Otto" or "Diesel"-cycle four-stroke internal combustion engine, having one or more cylinders however orientated, so designed and structurated as to be of very simple construction, capable of delivering a specific power and a number of rotations much higher than those that can be obtained - the cylinder capacity being the same - from the traditional valve engines; and this to weights and costs remarkably lower and with the advantage of emitting exhaust gases having a very low pollution degree.

As is known, the present mechanical engineering for internal combustion engines provides substantially for two types of engines, namely four-stroke engines and two-stroke engines, utilizing either the Otto or the Diesel cycle.

It is also known that four-stroke engines have many and great advantages relatively to the two-stroke engine; actually, gasoline four-stroke engines have a higher thermodynamical yield, a good cleanness as concerns exhaust gases, lower consumption and greater noiselessness compared to two-stroke engines which utilize as fuel a gasoline-oil mixture; anyhow, all these advantages involve a greater mechanical complexity, which in practice brings about an increase in weight and higher costs.

Two stroke engines, on the contrary, have only the advantage of being structurally simpler and of delivering a power greater that that delivered by four-stroke valve engines, which is obviosuly due to the fact that two-stroke engines - rotations being the same - have a double number of active phases, i.e. of explosions.

The application field of two-stroke engines is substantially limited to low displacement engines, where technical simplicity, low cost and low weight prevail; while four-stroke engines, usually the multicylinder ones, are largely used for means that require high power, such as motor-cars, transport motor-vehicles, racing-cars, and in all those cases where cost, mechanical complexity and weight are largely justified by the performances of these engines.

The attemps that have been made up to now to reduce the mechanical complexity and the weight of four-stroke valve engines do not appear to have brought about technically and practically acceptable results, such as to justify their utilization instead of the traditional two-stroke engines.

On the other hand, the mechanical-structural complexity of four-stroke engines, however improved, for instance through the adoption of head camshafts in order to eliminate tappets, is still practically unchanged. This is due to the fact that said mechanical complexity lies especially in the complex kinematic chain which constitutes the so-called "timing system", i. e. the whole constituted by two or more head valves for each cyclinder, the crankshafts for driving said valves either directly or through tappets, the geared kinematisms, chains or toothed belts which transfer the motion of the driving shaft to said crankshafts, which, in their turn, control said valves according to prefixed intervention phases to carry out the opening-closing cycle of the valves of each cylinder.

It is also well known that today internal combustion engines ("Otto" cycle, either utilizing gasoline or diesel), have the drawback of emitting highly polluting, and therefore noxious, exhaust gases, as fuel combustion is always incomplete due to the impossibility of obtaining, with the present structures of these engines, a perfect mixing in the combustion chamber between fuel and combustion supporter (oxygen from air); in fact, to obtain a perfect mixing between fuel and oxygen, a mixing on a molecular level should be achieved in each space of the combustion chamber according to substantially stoichiometric ratios.

In other word, it would be necessary to cause a powerful vortical motion of the components of the mix, which cannot be achieved because of the very short time in which the mixing takes place; besides, even the vortical motion of the components of the mix, caused by the shiftings of the piston, is never sufficient to allow a perfect mixing, especially in Diesel-cycle; this is due to the fact that said shiftings of the piston cause vortexes of the combustion components which are always subsantially axially orientated relatively to the piston skirt, which contrasts sharply with what is well known, i.e. that to obtain an ideal vortex, its axis should always be obliqually orientated relatively to the shifting direction of the members that generate the vortex. At present, in an effort to reduce air pollution caused by exhaust gases of today engines, special fuels, always very expensive, or catalytic silencers, very expensive too and heavy, are used.

There arises therefore the problem of realizing a one or multicylinder four-stroke engine, so designed as to sharply reduce the mechanical complexity and therefore also the weight and cost of today four-stroke engines with two or more couples of valves per cylinder.

Within the frame of this problem, the main object of this invention is the realization of an internal combustion four-stroke engine so constructed as to improve the present timing systems provided in the four-stroke engines that are now available, to reduce the weigh and cost of the engine, and to achieve a high noiselessness, consumptions lower than the present ones, and a reduction in overall dimensions.

A further object of the invention is the realization of an engine of the aforementioned type, so designed as to have, in practice, a structure simple

and compact enough to be mechanically comparable to a two-stroke engine.

Still a further object of this invention is the realization of a simplified and reliable four-stroke engine, and such as to allow the delivery of a specific power and a number of revolutions - displacement being equal - markedly greater than those of four-stroke valve engines, and the emission of exhaust gases having a very low content of unburned polluting substances.

These and still further objects which shall be more clearly disclosed by the following description are advantageously achieved by a four-stroke internal combustion engine, with one or more cylinders however orientated, wherein the piston skirt of each cylinder is separated from the latter and rotates in touch with the internal surface of said cylinder, without axial translation, at a speed equal to half the speed of the engine crankshaft, at least a port or window being provided on said rotatory skirt, such port or window being so sized and located as to be caused to coincide, dutring the rotation, with analogous intake and exhaust openings correspondingly provided in said cylinder, the rotation of said skirt being achieved by drive gearings means placed between said crankshaft and the lower end of said skirt, so as to allow, through the continuous rotation of said skirt at half the speed of the crankshaft, the realization of the four phases of the four-stroke cycle.

More particularly, to allow the rotation of the skirt, such drive gearing means are preferably constituted by a couple of conical gears, one of which is coaxially integral with the peripheral end of the skirt, and the other one is coaxially keyed on to the crankshaft which alternatedly drives the cylinder pistons.

Besides, always according to this invention, to achieve a rotation speed of the skirt equal to half the speed of the crankshaft, the number of teeth of the gearing integral with the skirt, in case of use of a conical couple, is twice the number of teeth of the gearing integral with the crankshaft. Just in the same way, in case of a kinematic chain with more than two gearings, the same half speed will be achieved with a 1:2 ratio between the number of teeth of the drive gearing and the number of teeth of the skirt gearing.

Further still, to achieve the correct realization of the four phases of the cycle (intake-compression-combustion and exhaust), the intake and exhaust ports have preferably a rectangular shape or of different shape, and are arranged at about 90° relatively to one another, the width of the bent side of each port transversal to the cylinder axis being such as to subtend an angle of about 45° with the apex on the axis of the cylinder and the relevant skirt, the port provided in said rotatory skirt being also rectangular and the cross-dimension of said port corresponding to an angle of about 45°, in order to reach a perfect closing of the combustion chamber during the compression and expansion phases. In practice, said angles of the ports are slightly different from 45°, to allow an anticipated intake and a delayed exhaust, such as to optimize the thermodynamic yield of the engine.

Further characteristics and advantages of this invention will be more clearly disclosed by the following detailed description, wherein reference is made to the drawings, which are to be construed as non limitative examples, wherein:

Fig. 1 is an axial-diametral schematic section of the cylinder of a four-stroke, rotatory skirt alternating engine, realized according to this invention;

Figs. 2 and 2a are respectively the axial and through-sections of the same cylinder of Fig. 1, with the rotatory skirt in the positions required for the realization of the four phases of the "Otto"-cycle or the Diesel-cycle;

Fig. 3 is a magnified through-section of a section of the cylinder of Fig. 1, along the A-A line of said figure;

Fig. 4 is an axial section of part of a multicylinder engine utilizing the rotatory skirt cylinders which are the subjet matter of this invention;

Figs. 5 and 5a are sections of a mechanical and functional variant of the rotatory skirt engine of the preceding figures;

Figs. 6 and 6a are a section and top view respectively of still another embodiment.

With reference to said figures, and in particular to Figs. 1 to 3, the four-stroke internal combustion engine realized according to this invention utilizes substantially the general structure of a traditional alternating engine, namely: a finned cylinder 1, closed on top by a head 2 with an ignition sparking plug 3 and a piston 4 alternatively tight-translable within a skirt 5 and driven by a connection rod-crank system 6-6a, which drives, in its turn, a shaft 7 whose axis is perpendicular to the alternating stroke of the piston; in case of a multicylinder engine, the connection rod-crank system is constituted by a single device, known as crankshaft.

One or several couples of poppet valves opposed to closure return springs are provided within head 2, which return springs realize, through a programmed opening-closure cycle driven by a camshaft and through the programmed ignition of the sparking plugs, the four-strokes of the Otto-cycle.

The four-stroke engine realized according to this invention involves practically a sharp simplification of the above mentioned traditional valve engine, as it entirely eliminates the so-called timing system provided for the interventions of the valves,

i.e., substantially, valves, return springs and camshafts, possible tappets, and the complex gearing or toothed belts system necessary for the drive from the crankshaft and the transmission of the motion to the camkshafts.

Said technical simplification is achieved, according to this invention, by realizing piston skirt 5 separated from the related finned cylinder 1, causing the former to rotate within said cylinder, and in touch with the internal surface of the latter; different oil-film lubricated metals can be utilized as well as other systems such as ball bearings or the like. Said skirt 5 is provided at its upper end with a ring 5a and at its lower end with a belling 5b, caused to be rotatorily engaged, respectively within a notch 1a and a bell-shaped flaring 1b provided on the opposite ends of the cylinder; the function of the ring and the lower bell is that of preventing axial translations of the skirt from taking place within the cylinder which holds it. Bell 1b has also another function which shall be clearly explained later on.

A port or window 8 having a substantially quadrangular and preferably rectangular shape or section is provided in the upper part of skirt 5, the greater side of said port being in vertical position and the smaller side being horizontal and perpendicular to the axis of the piston stroke. At the same height as port 8 of the skirt, two corresponding ports 9 and 10 are provided in the cylinder 1, having each an area wich is substantially equal to the area of the skirt port, so as to allow, during the rotation of the skirt relatively to the fixed cylinder, a perfect coincidence between said ports.

The continuous rotation of skirt 5 is obtained by means of a couple of conical gearings 11-11a (Fig. 1), of which the one indicated by 11 is integral with the periphery of bell 5b forming one only body with skirt 5, and the one indicated by 11a is keyed on to crankshaft 7.

To allow the consecutive realization of the four phases of the cycle, skirt 5 should reach and mantain a rotation speed equal to half the speed of the crankshaft, and to this aim the number of teeth of gearing 11, integral with the skirt, shall be twice the number of teeth of gearing 11a integral with shaft 7 (Fig. 11). Besides, the maximum length of the bent horizontal side 8 and 10-9 of said rectangular ports is limited by the bore of the relevant cylinder. In fact, as Fig. 3 shows, the horixontal side of port 8 of the rotatory skirt and of the fixed intake and exhaust ones 9-10 shall have in any case a length such as to subtend a maximum angle of 45° whose apex coincides with the median vertical axis of the skirt; if the angles should exceed 45°, there might arise the drawback of a partial communication between intake and exhaust during the rotation of the skirt.

The choice of the width of the skirt's port and of the intake and exhaust ports do not depend only on the size of their horizontal side, but also and especially on the size of the vertical one; actually, said vertical side (indicated, for the sake of clearness by "1" on Fig. 2), may also be greater - and even by far - than the horizontal side; in some cases, the length of the "1" side may arrive up to half the stroke of the cylinder or even at the lower dead point.

Therefore, by a suitable design of the ports, one can maximize the intake and exhaust sections of the engine, facilitating in this way the flows of the air-fuel mix and the scavenging of exhaust gas from the combustion chamber 13; this opportunity allows in practice to reach a maximum number of revolutions as well as a specific power markedly higher than those which can be obtained from the present four-stroke valve engines.

As proof of the above explanation, the fact is that the advantages achieved by this rotatory skirt engine with ports varying in width and number according to the utilization requirements of the engine, cannot be achieved even by the engines with several head valve couples; this is demonstrated by the fact that in the rotatory skirt engine one can obtain ports or windows whose area is equal or greater than 30% the area of the cylinder or skirt section, while in valve engines one can never provide, at half-head, for as many valve housings having a total section equal to 30% the area of the cylinder's through-section.

A further advantage which is obtained with the engine subject matter of this invention lies in that it does not cause, thanks to the absence of valves, any trouble to the intake and exhaust flow by the poppet valves, avoiding in this way a great energy loss (only partly given back) necessary for the compression of the return springs of said valves.

The sequence of the strokes of the four-stroke cycle realized by the above described simplified engine is clearly illustrated on Figs. 2 and 2a; on said figures one can see, for each stroke, the position of the skirt port relatively to the cylinder and to the intake and exhaust ports.

Always according to this invention, the simplification described with reference to Figs. 2 and 3, relatively to one only alternating piston cylinder, is validly realizable also in multicylinder engines, as shown on Fig. 4.

In this engine, 1 indicates the cylinder block with several cylinder, whose respective rotatory skirts 5, 5c, etc., engaged to one another, are mounted inside each of them. In this case, the "even" rotatory skirts rotate in contrary direction relatively to the "odd" ones, as only one couple of conical gearings 14, integral with shaft 7, is provided for the rotation of all the skirts. This involves,

in practice, the alternate positioning (on the right and left side of the cylinder block) of the intake and exhaust ports. This fact can be made up for by introducing a further gearing between the horizontal gearings of each adjoining couple of rotatory skirts. A further solution to cause all of the skirts to rotate in the same direction is that of providing for each cylinder an own conical couple, as is the case of Fig. 1.

Obviously, in practice other solutions can be provided to cause all of the skirts to rotate in the same direction, the choice of any solution being dependent especially on the construction costs and the overall dimensions allowable each time.

Besides, the rotatory skirt subject matter of this invention can be usefully applied also in the field of small engines which are normally two-stroke engines; in this case, the slight mechanical complication (conical couple and rotatory skirt) is largely made up for by the higher thermal yield.

Always according to this invention, the continuous rotation of the skirt can be utilized to cause and synchronize the sparkle of plug 3 at each combustion phase, avoiding in this way the present complex and cumbersome system constituted by the coil ignition, platinum points and rotatory contact breaker; the ignition of each cycle can in fact be obtained (Figs. 5-5a) by applying to the upper end of the skirt a conducting tang 14, protruding horizontally inside the skirt, as is clearly shown by section B-B of Fig. 5 and on Fig. 5c, in such a way as to brush against the end of electrode 3a of plug 3 during the rotation of said skirt, the electrode being "high-voltage" fed through a simple coil.

The distance between the plug electrode the moment when it is brushed against and the tang will be shorter than the arc distance of the current at the electrode, so as to cause said arc to shoot out. The current may be either alternate or direct.

The angle position of said tang relatively to the cylinder ports can be so chosen as to cause the sparkle to shoot out with a given "advance" relatively to the upper expansion-combustion dead point.

In practice, this simple device provides also the advantage of reducing pollution. In fact, thanks to the smoothness of the engine (due to the absence of springs to be compressed), one can adjust the dimensions of the tang and the electrode, causing an abundant current flow to pass, which causes in its turn the electric power of the sparkle to surpass the power dispersed through friction when the engine is idling or neutral. In this case, the idling or neutral engine can run on pure electric current, with no fuel consumption; in this way, in idle and neutral conditions, there would be no pollution at all.

One would have therefore a no-pollution sparkle and piston electric engine in idle and neutral conditions, and a traditional internal combustion cycle in all the other cases.

The technical simplicity of this rotatory skirt engine may find a useful application also in the field of micro-engines for models and similar utilizations, with the great advantage of eliminating the usual incandescence spring plugs for the ignition, and of not requiring the usual costly fuel-mixes necessary to avoid combustion advances (knocks). In conclusion, this rotatory skirt engine can be utilized for gasoline-oil mix engines, without the aforementioned complications.

Besides, always according to this invention, the utilization of said rotatory skirt allows to realize an optimal mixing of fuel and combustion supporter (oxygen from intake air), reducing drastically the pollution caused by exhaust gases.

This result is achieved, both in the case of one cylinder engines and in the case of multicylinder engines, by providing above the upper dead point UDC (Fig. 6) one or several fins or protruding elements 16-16a, etc., shaped as helical blades like those of fan wheels or the like, which come out horizontally from the internal wall of the rotatory skirt 5 and are radially orientated. Said blade or blades 16-16a are located above the intake openings 9 provided in the rotatory skirts, so as to allow, possibly in combination with more intake openings 9-9a (Fig. 6) inclined upwards, the creation in the combustion chamber of an acceleration of the vortex of the intake mix created by the rotatory skirt, together with an upwards inclination of said vortex, optimizing in this ways the mixing.

In all of the aforementioned embodiments, an oil circulation is provided between said cylinder and the relevant rotatory skirt, said oil being delivered by the usual oil pump through coil-channels or the like, provided in the cylinder wall.

Lastly, from the above disclosure one clearly understands that further modifications and mechanically and functionally equivalent variants may be introduced in the engine subject matter of this invention, without exceeding the protection scope of this invention.

Claims

1. Four-stroke internal combustion engine with one or more cylinders, having a simplified structure, characterized in that it provides for the piston skirt of each cylinder to be separated from said cylinder and to rotate in touch with the internal surface of said cylinder, without axial translation, at a speed equal to half the speed of the engine crankshaft, at least a port or window being provided on said rotatory

skirt, which port or window is so sized and located as to allow its being caused, during the rotation, to coincide with analogous intake and exhaust openings correspondingly provided on the cylinder, the rotation of said skirt being obtained by gearings means placed between said crakshaft and the lower end of said skirt, so as to allow, through the continuous rotation of said skirt at half the rotation speed of the crankshaft, the realization of the four phases of the four-stroke cycle.

2. Engine according to claim 1, characterized in that said gearing means for the transmission of motion to said skirt are constituted by a couple of conical gearings, one of which is co-axially integral with said skirt and the other is axially integral with said crankshaft.

3. Engine according to claim 1, characterized in that the gearing of said conical couple integral with the skirt has a number of teeth wich is twice the number of teeth of the other gearing, in order to allow the skirt to rotate at half the speed of the crankshaft.

4. Engine according to claim 1, characterized in that said skirt port has a substantially rectangular shape, with its bent side horizontal and transversal relatively to the cylinder axis, and such a width as to subtend a 45° angle centered on the cylinder axis, the intake and exhaust ports provided in the cylinder having also a rectangular shape, with an horizontal side such as to subtend a 45° angle.

5. Engine according to one or more of the preceding claims, characterized in that it is realizable also in the case of several cylinders however placed relatively to one another, the rotatory skirt of each of them being driven either by an own couple of conical gearings or by direct engagement of the gearings of the individual skirts among one another, or also by means of an additional gearing placed between the gearings of the "even" skirts, in order to allow, in this last case, the rotation in the same direction of all the skirts.

6. Engine according to the preceding claims, characterized in that it provides a conducting tang on top of each rotatory skirt, which tang protrudes towards the inside of said skirt, and is suitable to allow the formation of the ignition sparkles in the combustion phases, during the rotation of the relevant skirt, due to the brushing of the tang against the end of the central electrode of the ignition plug, the positioning of said tang being so adjusted as to allow the realization of the ignition advance, relatively to the piston upper dead point, as required according to each case.

7. Engine according to the preceding claims, characterized in that it provides for the delivery, between said electrode and said tang integral with the rotatory skirt, of an arc electric current capable of causing the rotation of said engine in the idle and neutral conditions by electrical energy only, in absence of fuel, and therefore with no pollution at all.

8. Rotatory skirt engine according to the preceding claims, characterized in that it is so designed as to be suitable not only for four-stroke engines, but also for micro-engines for models and the like.

9. Rotatory skirt engine according to the preceding claims, characterized in that it provides above the upper dead point of each rotatory skirt cylinder at least a fin or the like, substantially a partly helical blade, coming out from the skirt's internal part and horizontally placed above the intake ports, so as to allow a substantial optimization of the mixing of the sucked mix.

10. Rotatory skirt engine according to the preceding claims, characterized in that it provides several intake ports substantially upwards bents, suitable to promote the formation of an obliquous vortex of the sucked components, and therefore a substantial reduction in the unburnt components in exhaust gases.

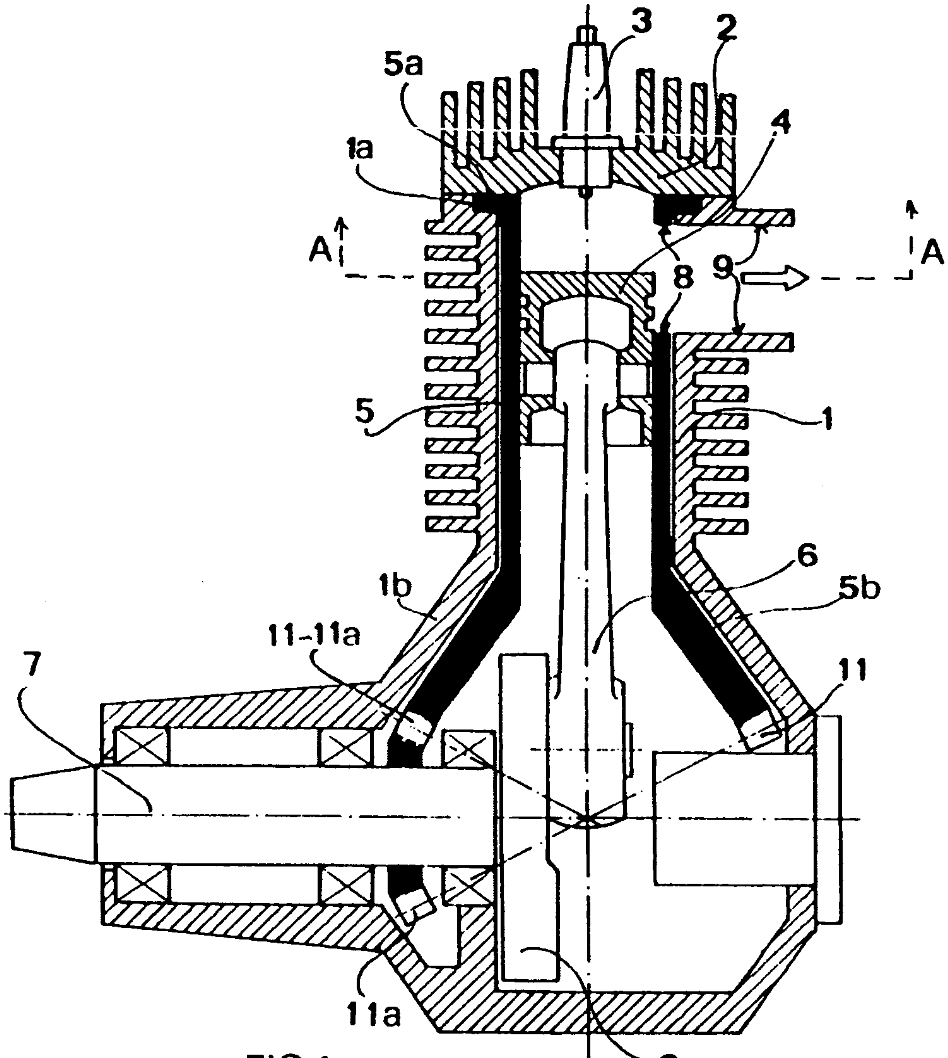


FIG.1

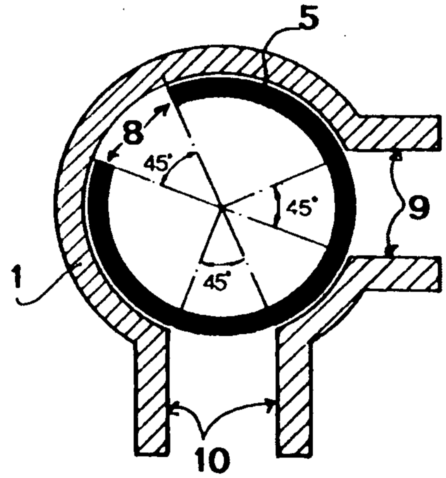


FIG.3

FIG.2

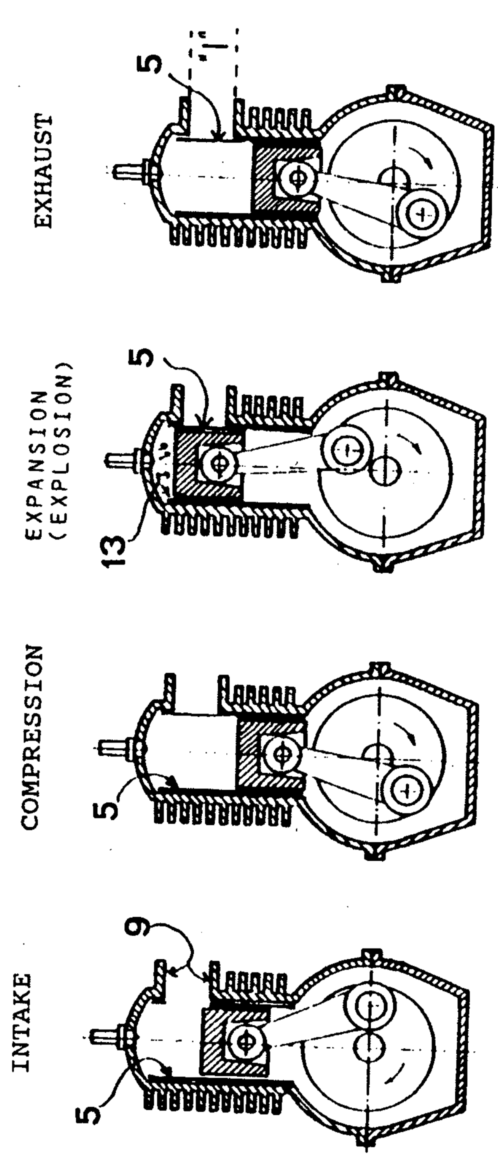

INTAKE
COMPRESSION
EXPANSION
(EXPLOSION)
EXHAUST
5
9
13
"l"

FIG.2a

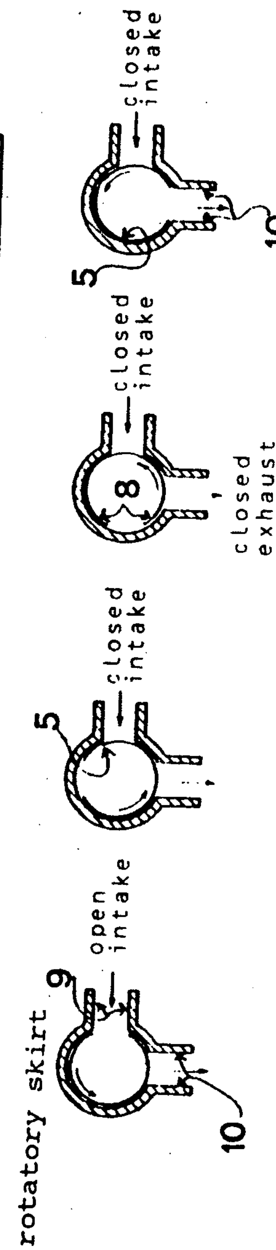

rotatory skirt
open
intake
closed
intake
closed
exhaust
5
8
9
10

FIG.4

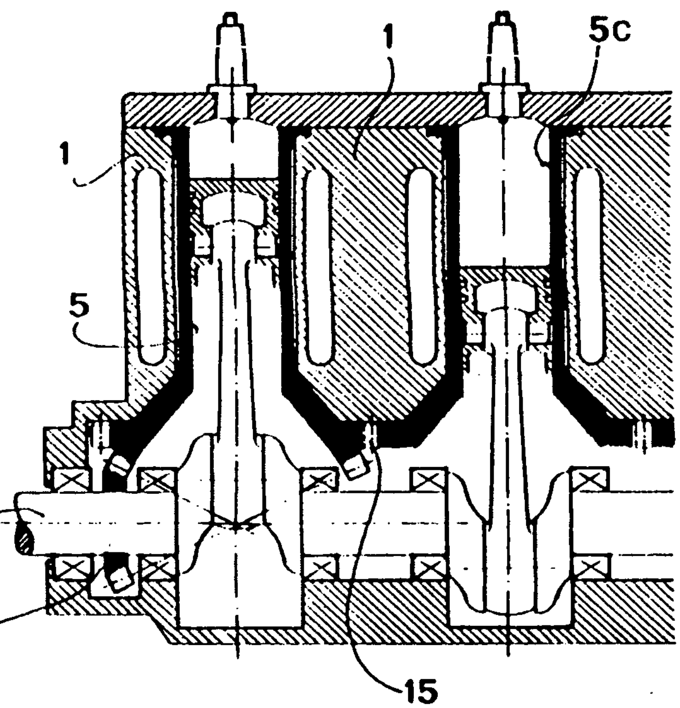


FIG.5

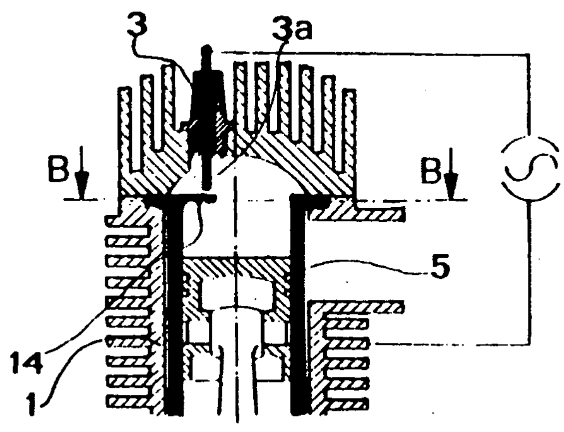
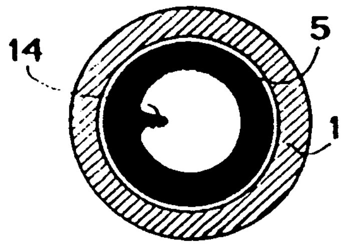


FIG.5a



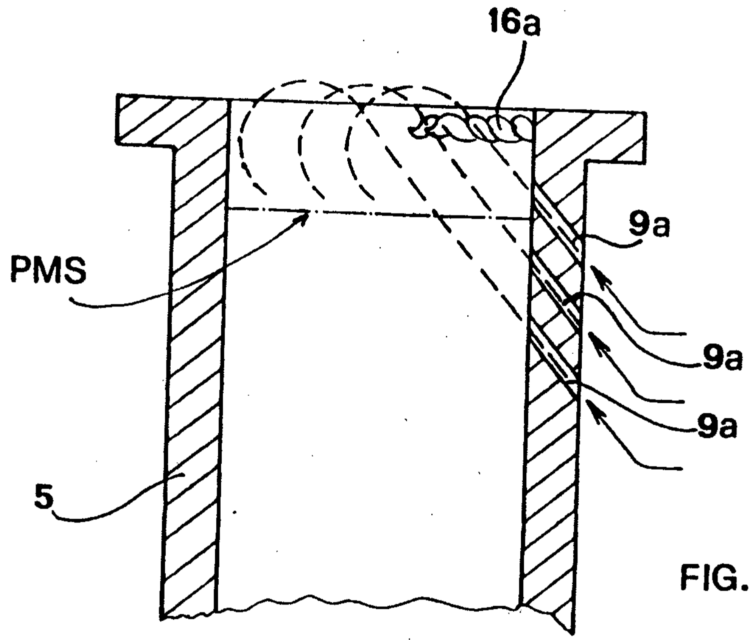


FIG.6

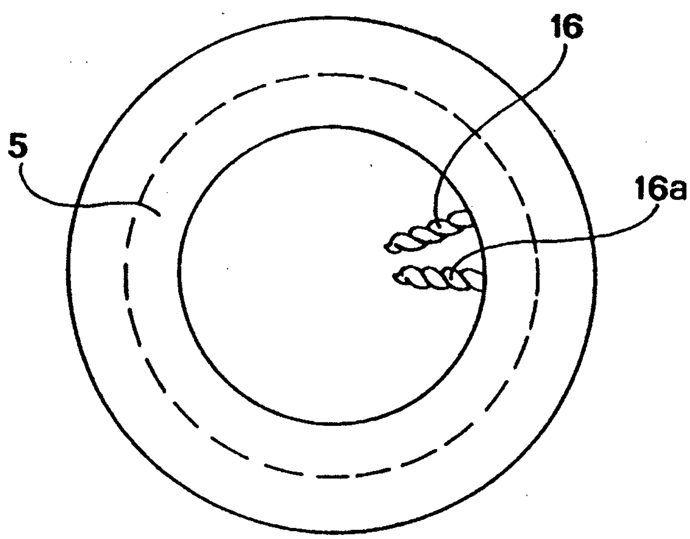


FIG.6a

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